Mapping ontologies and contexts: from theory to a case study

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Abstract: Ontologies are used actively as a knowledge representation, retrieval and navigation tool to improve knowledge sharing, exchange and communication. In order to provide effective communication ontologies should be mapped with the context. This paper analyses existing approaches towards the very definition of context and suggests two context types. Requirements for effective knowledge representation based on two context types and on mapping ontologies and context are suggested. These requirements are considered and factored in the following case study by consecutive mapping different context types and content ontology . This case study describes Knowledge Navigator – a map that relates contents of Formalized Management methodology with the corresponding context in order to reach effective knowledge communication to end users.

1 INTRODUCTION.

Nowadays organizations implement special tools and technologies to share, exchange and communicate knowledge. In order to be effective, these tools and technologies must provide users with relevant information in due time without being flooded with irrelevant data. To support the sharing and exchange of knowledge both among information systems and people it is useful to define ontology [6]. Now ontologies are already employed in portals, corporate memories, e-commerce and other knowledge management systems (see [1], [2], [11]). With respect to human-computer interactions ontology often works as a representation, retrieval and navigation tool. In playing such a role ontology usually specifies the Content of knowledge resources. Such an ontology can be called Content ontology.

There are two problems that render the usage of Content ontology less efficient.

1. A Content ontology user is unable to set links between his/her task, problem, situation and notions in the Content ontology, thus he/she is unable to transform information into action.

"In many situations a content ontology user may not know the details of a solution, but he knows the details of his problem" [2].

"One of the fundamental tenets of knowledge management is that knowledge must link to and improve business processes. Without a map of the processes, goals, and knowledge assets inside one's organization, it will be difficult to reach one's destination." [14]

2. A Content ontology user is unable to match his/her personal mental model with notions in the Content ontology because of semantic and syntactical specialties of a person and ontology-creator.

This problem is taken from an elaborated field of semantic web where it is known as a mismatch between ontologies (see [5], [9]) (it is suggested to use analogy between ontology and personal mental model in the paper).

All these problems are related with the notion "context". These problems make problematic effective knowledge sharing and communication. In order to solve these problems it is necessary to define context and make explicit mapping between content ontology (or knowledge resource directly) and context. In the paper [Section 2] describes existent approaches to a context definition and mapping context and ontologies. [Section 3] marks out two context types and suggests the requirements for effective knowledge representation with respect to these types. [Section 4] initiates case-study and describes real-life knowledge communication task and corresponding problem. Knowledge Navigator (KN) is suggested as the solution for this knowledge communication task. [Section 5] suggests KN framework and brief description, which satisfies requirements from [Section 3] and is based on a consecutive mapping different context types and content ontology.

2 DEFINITION OF CONTEXT AND RELATED WORK

In [1] it is suggested to focus on the context as highly relevant for retrieval within an organization. In modeling the context the authors deal with two issues:

- the intended application context of a knowledge item, and
- the context a knowledge item was created in.

The Authors suggest that information context be expressed in terms of the *organizational structure and the process models*. These in turn are expressed in terms of the *enterprise ontology*. The design of the enterprise ontology is built on insights and developments from the enterprise modeling, business process modeling, and organizational modeling in knowledge-based systems [13]. In [2] a similar approach is used for semantic mapping between the sellers' supply and buyers' needs at an electronic knowledge market.

Similar enterprise ontology oriented approach to the context definition can be also found in the knowledge mapping technologies [4], [14].

The definition of context described above resulted from the knowledge management field, whereas in the semantic web field there is another useful definition of the context.

According to [3] *Ontologies* are *shared* models of some domain that encode a view which is common to a set of different parties

Contexts are *local* (where *local* is intended here to imply *not shared*) models that encode a party's view of a domain [7].

The authors argue that an ontology is contextualized, or that it is a *contextual ontology*, if it is kept local (and therefore not shared with other ontologies) but its contents are put in relation with the contents of other ontologies via explicit mappings. This mapping provides syntactic and semantic interoperability and deploys a variety of methods, coming from very different areas. They include: linguistic, statistical, structural and logical methods (see [5], [8], [9]).

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3 MODEL OF CONTEXTS AND REQUIREMENTS FOR EFFECTIVE KNOWLEDGE REPRESENTATION

Resuming Section 2 there are two main definitions of context that affect communication problems (Section 1):
Def 1. Context model reflects:

- the intended application context of a knowledge item, and
- the context a knowledge item was created in.

and is expressed in terms of the *enterprise ontology*.
Def 2. Contexts are *local (not shared)* models that encode a party's view of a domain.
In order to distinguish types of context and set requirements for knowledge representation working definitions are suggested for every type of context. The first working definition is based on a semiotic model [10]. Traditionally the semiotic model includes:

- Syntax which reflects rules and relations between signs of any language
- Semantics which reflect relations between signs and their meaning
- Pragmatics which reflect relations between signs and their users and creators

This model together with Def 1 makes possible to consider the context in Def 1 as *pragmatic context*.
The Context in Def 2 will cover all the components of the semiotic model making it impossible to define it uniformly in terms of a semiotic model. Thus the context in Def 2 will be termed and used in this paper as *local context.*
Pragmatic context can be either shared or not. Consequently the former is represented by ontology and the latter is by a set of local contexts.
The requirements for effective knowledge representation which provides for a solution of the problems from Section 1 are as follows:
Requirement 1: Every ontology must be either shared by *all* the communication participants *or* be mapped with corresponding local contexts of every participant (group of similar participants).
Requirement 2: Every knowledge resource must be mapped with a pragmatic context (either directly or by means of the content ontology).
These requirements are further considered and factored in the case study.

4 CASE STUDY: TASK SETTING AND PROBLEM DESCRIPTION

Formalized management methodology ("methodology" further in the paper) is a product of the management consulting company BIG-Petersburg. This methodology is initially presented in the form of a book, but the concept "Formalized Management Methodology" is used due to the plans of application of other media, such as e-books or knowledge portals.
This methodology reflects the experience of consultants gained during business process improvement and restructuring of organizations in Russia and CIS countries.
The goal of this methodology is to help different organizations in solving their managerial problems and improving levels of management. Thus the main objective is to provide each potential organization based user of the methodology with necessary knowledge to help realize the tasks and functions they face.
In order to achieve this objective the methodology must be effectively communicated to its potential users. Although methodology is well-structured with a content ontology (=table of contents) and divided into topics (content ontology nodes) it is rather hard to communicate it because the way the methodology can be used, its potential users and the methodology itself have their own specialties. These specialties can be considered as communication problem and are as follows:

a. Different organizations that intend to use the methodology face different problems and tasks. Many problems and tasks do not require usage of every topic of methodology.
b. Implementing such a methodology is not a task faced by one person or a small group only; it requires a joint effort made by many persons employed in the organization. As a result the target audience for the methodology implemented is very broad and involves many people in a management activities oriented organization (ranging from directors' boards to linear managers). It is a subset of topics that is to be read and learned by a majority of users' categories.
c. The core of the methodology integrates words quite unusual and new for the majority of Russian managers (Corporate / Enterprise Architecture, Business Engineering). In addition management research and practice have no conventional terms and concepts. Thus words and phrases used in the methodology and especially in the topic headings can be misunderstood and users will be unable to set a relation between their mental models and topics of the methodology.

In order to effectively communicate methodology with respect to the specialties described above Knowledge Navigator (KN) was created.

5 CASE STUDY: KNOWLEDGE NAVIGATOR FRAMEWORK AND DESCRIPTION

Input data for KN are content ontology and the very content.
In order to satisfy the requirements for effective knowledge representation KN – end-user solution – integrates three tools (Figure 1):

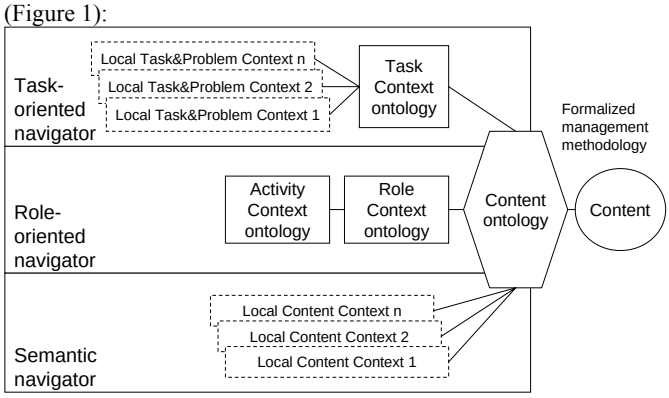

Figure 1. Knowledge Navigator Framework

1. Task-oriented navigator ("What for" – navigator)
   It helps users to choose topics to solve certain tasks and problems of organization.
   This navigator maps content ontology with Pragmatic context, which is represented in the form of Task Context ontology. But although the latter ontology results from the analysis made by a consulting company and is shared by the authors, it is not shared by prospective users and consequently does not satisfy Requirement 1 from [Section 3]. In order to help the users identify their local problems every node in Task Context ontology is mapped with a set of descriptive local task and problem contexts of users. These local contexts are given even

in user linguistics. Finally users of this navigator do two consecutive mappings, see Step 1 and Step 2 in Figure 2.

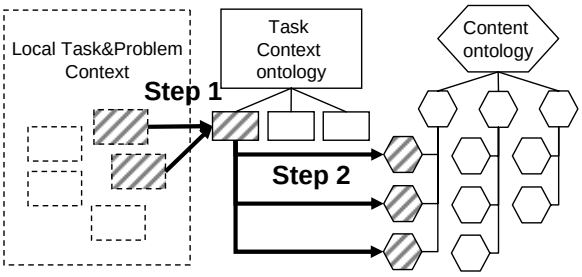

Figure 2. Task-oriented navigator - two consecutive mappings

Real-life example for shaded blocks from Figure 2 is represented in Table 1.

Table 1. Task-oriented navigator – example

Local Task&Problem Context	Task Context ontology	Impor-tance	Content Ontology /Topics
1. You might have encountered situations of complete chaos resulted from disorganization in your company. These cause the same problems to reoccur. --- 2. The strategy issues are left unheeded in your company. The main question your company managers are faced with is "how to cater to the clients' order"	To establish order	○	Business Engineering and modeling
		△	Corporate Architecture as a control object
		⊙	Tools of Business Engineering

Importance:	⊙	Critical	○	Important	△	Useful

2. Role-oriented navigator ("Who" – navigator)
   It helps users to choose topics for learning with respect to their Roles in the organization.
   This navigator maps content ontology with Pragmatic context, which is represented in the form of Role Context ontology. Similarly to task-oriented navigator, Role Context ontology is ambiguous and polysemantic for the users, because Roles (nodes of Role Context ontology) can bear different responsibilities in different organizations. Thus the Role Context ontology is mapped with the elements derived from the next Pragmatic context - Activity Context ontology. The Activity Context ontology can be considered as shared by potential users, because all the management activities presented are typical for different organizations. Finally users of this navigator also do two consecutive mappings, see Step 1 and Step 2 in Figure 3.

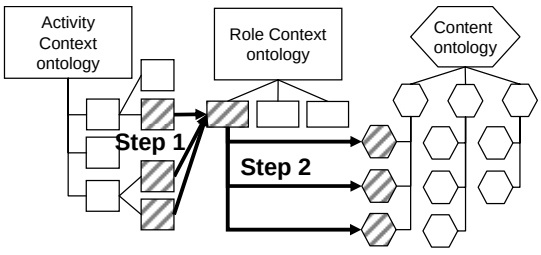

Figure 3. Role-oriented navigator - two consecutive mappings

Real-life example for shaded blocks from Figure 2 is represented in Table 2.

Table 2. Role-oriented navigator – example

Activity Context ontology	Role Context ontology	Impor-tance	Content Ontology /Topics
Perform external and internal analysis	Director of Business Development	⊙	Ideology of modern organization
Develop business strategy		○	Business Engineering and modeling
Develop and set organizational goals		△	Corporate Architecture as a control object

3. Semantic navigator ("What about" – navigator)
   This navigator helps users to relate topics in authors language with their knowledge and thus refine a subset of topics to learn. This navigator maps the Content ontology with the Local Content Contexts, which are represented by the keywords.

Namely this combination of 3 tools together with internal mapping will provide effective communication. Such a framework of KN takes into account knowledge communication specialties (problem) from [Section 4] and satisfies the requirements from [Section 3].

6 CONCLUSIONS

This paper suggested the requirements for effective knowledge representation based on mapping ontologies and context with respect to two types of the latter. It described a solution for real-life knowledge communication task called Knowledge Navigator. This solution illustrated consecutive mapping ontologies and contexts – mapping which was necessary to effectively communicate knowledge to different users, which solve different tasks and have different understanding of domain and background.

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